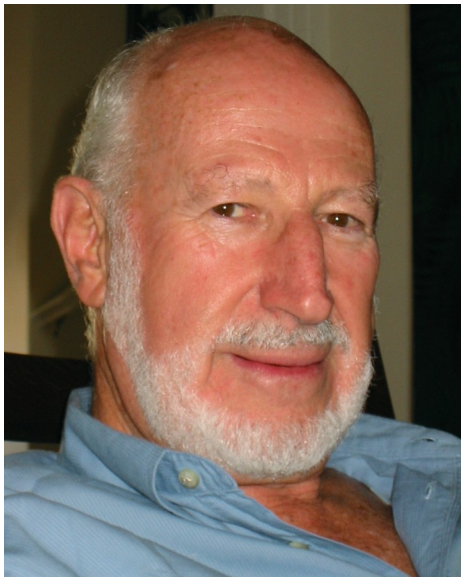
"...It was pretty natural after investigating the kind of data a computer generated (burst & random) to design a Packet Switched Network (ALOHAnet) which fulfilled the needs of a computer, rather than using a classical Circuit Switching, designed for telephony..."

NORM ABRAMSON ALOHA-net (the first Packet Radio Network[1]) Inventor.

Predecessor of the Ethernet and first to interconnect with ARPAnet in 1971.



Interviewed on September 15, 2004 in San Francisco, California..

Born in Boston Massachusetts on April 1st 1932. He studied in Physics at Harvard (1953) as an undergraduate and a Masters in University of California Los Angeles (UCLA, 1955). He moved to Stanford University where he obtained his PhD in Electrical Engineering (1958). Later he obtained a position as a faculty member till 1964 when he was a visiting Professor at Harvard (64-65). He has also held visiting faculty appoint-ments at Berkeley and at MIT. A trip to Tokyo stopping in Hawaii for surfing, (his hidden passion) made him decide to live there, so for almost 30 years (1966 to 1994) he was a Professor of Electrical Engineering and a Professor of Information and Computer Sciences at the University of Hawaii. Where he served as Chair of the Information and Computer Sciences department and as Director of the ALOHA System research project. He directed the effort at the University of Hawaii which led to the construction and operation of the ALOHAnet. The first packet switched radio network. He has served as Consulting Expert in Communication Systems, Data Networks and Satellite Networks for the International Telecommunications Union (ITU, Geneva), UNESCO (Paris) and the UNDP (Jakarta). He was a founder and first CEO of ALOHA Networks in San Francisco (1994) and founder, Vice-President and CTO of Hokupaa (2004).

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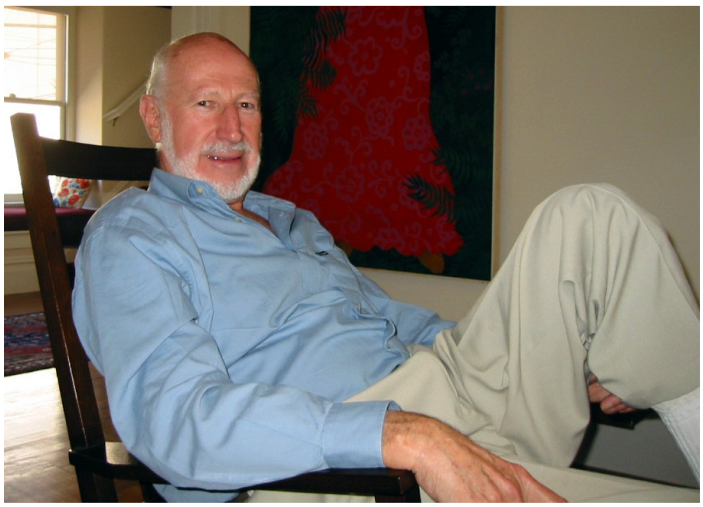
www.harvard.edu www.mit.edu
www.ucla.edu www.stanford.edu
www.hawaii.edu www.hokupaa.com
www.alohanet.com - New technologies for Internet (bi-directional) Over Satellite access.

[1] ALOHAnet is considered the Mother of the Ethernet. See Bob Metcalfe's interview. ALOHAnet was the first network to be connected to the ARPAnet.

Do you remember when you had your first contact with a computer?

Yes I do, it was in January of 1953. I was studying Physics at Harvard. It was with one of the very first computers that ever existed. The MARK II. Personally with Howard Aiken[2]. After that (during my part-time job) I used computers at Hughes Aircraft Company (CA) in their Systems Lab (summer of 1953)

What was your first contact/experience with Internet or ARPANET?



My first exposure to ARPAnet was one year after I arrived to Hawaii, when I went over to Washington (Pentagon facilities) to talk with Bob Taylor[3]. Larry Roberts was there. I was looking for some support, for our research. They had ideas of building a network, although not via radio as ours. This was late 1967 to early 1968. We proposed that project because it was a very interesting thing to build at that time. Despite the terrible communication and phone systems and services we had in Hawaii, that wasn't the main motivation, but it was the perfect excuse to have our project funded. When Bob Taylor quit ARPA to go to Xerox PARC, Larry Roberts funded the ALOHAnet project. We were then the first digital radio network to be "always on" non-dialup[4] and connection free. Before designing the network, we studied the patterns and characteristics of the data to be send. Computers send

[2] Howard Aiken, 1900-1973. He designed the Mark I, and Mark II, granted by IBM's first CEO, Thomas J. Watson. He created the Computer Lab in Harvard, and one of the first Masters and PhD programs in Computer Science.

[3] Bob Taylor: In that moment Director of the ARPA office. See his interview.

[4] Dial-Up: Referred to networks were you must dial a number to access. Like the conventional Telephone Network

small amounts of information in random small periods of time. Like bursts. So in this case, the telephone dialup oriented networks, were not suitable to manage this kind of data patterns. That produced too much overhead[5]. This is today a big issue: In a typical web surfing session about 99.9% of the information sent from user to the internet (in an Ethernet connection) is over-head. The upstream link has become terribly inefficient. As an example we can see that when we "click into a link" browsing the internet, the fundamental information-data to be transferred maybe is one or two bytes. But that must be translated for HTTP[6] and then error control and correcting protocols are added. So finally you send 5,000 bytes for that one click. This problem is serious if we realize that in satellite and radio internet access systems 90% of the cost is in the upstream link (from the user to the network). Which makes this part of the system very very inefficient. So there are a lot of possibilities for a company there.

In your opinion, what are the key characteristics of Internet?

- I would like to highlight the anarchy aspects of the internet. Versus the overregulated telecommunications world that we have seen in the 80's. One of the best things has been to not to have to deal with telecom bureaucrats.

- The inefficiency of resources. I can't tell you any other technology where inefficiency is so pronounced in a key part of that technology.

[5] Overhead: Any bit in a digital data stream other than an information bit. Also called a control bit or, simply over-head. The digital information transferred across the interface separating the user and the telecommunication system (or between entities within a telecommunication system) for the purpose of directing or controlling the transfer of user information. In some cases the amount of control-data sent is bigger than the information-data we want to transmit.

[6] HTTP: Hyper Text Transfer Protocol. Protocol which manages the communication between a browser & a web server.

It is not a bad design. It was good at the 70's for symmetrical telecom services, but not anymore.

The ALOHAnet radio system. In Honolulu (Oahu Island, Hawaii - USA)

What do you consider the most important milestones in the development of the network?

As achievements of the ALOHAnet:

1971 A satellite (64Kbps) channel connected ALOHAnet with the ARPAnet

1971 A NASA satellite[7] connected us to Alaska, Japan & Sidney (Australia)

As achievements of the Internet:

1970 The establishment of a true routing network.

1975-1980 the development and deployment of internet protocols

which permitted to expand the network as we know it today.

How did you contribute to the development of the ARPAnet?

[7] NASA Satellite was ATS-1: Advanced Technology Satellite.

- I directed the project which first did Digital Radio Communications. Starting at the end of 1968 in Hawaii.
- I proposed the Random Access ALOHA radio channel. We design and built the equipment and implemented the network within the Hawaiian Islands. The ALOHAnet was running at 1970. Just when the first microprocessor was released from Intel. So we[8] integrated that technology to our network. It was working 3 years with the

support of the National Science Foundation, ARPA and IBM. But in the Vietnam era, the relations between ARPA and Universities went through pretty difficult times. And the project continued but without money to build more features. The university never really used the network internally. We used it to access our central computer and to be in touch with other University of Hawaii campuses (in Oahu, Big Island, and Maui). We covered via UHF[9] radio and packet repeaters more than 400 Km.

Who are some key people in the development of Internet, leaders ?

Larry Roberts for being a key driving force in the ARPAnet development and in ALOHAnet[10] too.

Bob Metcalfe, he convinced his boss just arriving to Xerox PARC, to send him to Hawaii. He spent 6 months working together with us as a postdoctoral. And he did something quite different. Taking the ALOHA

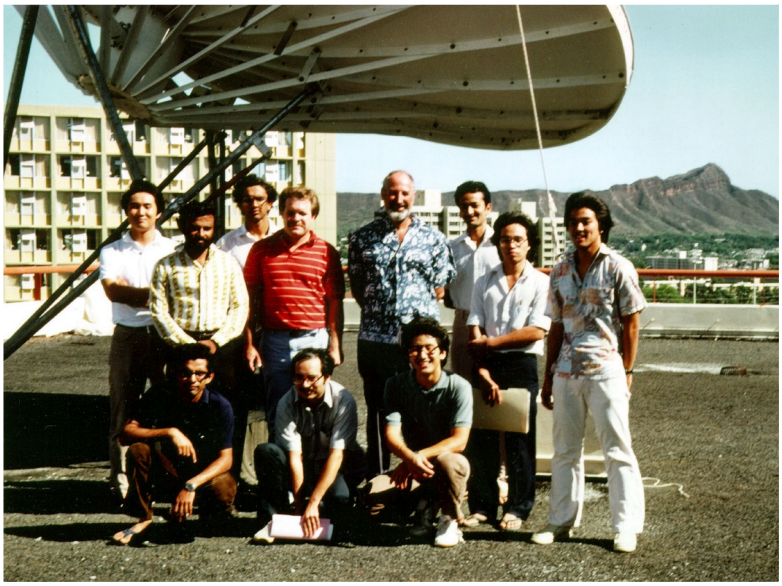
[8] Chris Harrison was the engineer who upgraded ALOHA equipment to include a microprocessor.

[9] UHF: Ultra High Frequency. Name the frequency range from 300 MHz to 3.000 MHz.

[10] He was the first who came up with the Slotted ALOHA Channel concept. So he wasn't only a manager.

Radio (which has two channels, one to go and one to come back) and putting them together in the same cable. Which was more difficult to manage, so he came with the
CSMA/CD[11] protocol, which was detecting collisions.
The **BBN Group** and especially the team leader **Frank Heart**. For designing and building the IMP, TIPs and later the SIMPs[12] which were the foundations of the ARPAnet.
Paul Baran for his original ideas of packets and routing.
In Hawaii I would like to remember Professors Frank Kuo, **Ned Weldon**, **Tom Gaarder**, and **Wes Peterson** faculty members who participated in the research program and **Alan K. Okinaka**, Dave Wax, **Chris Harrison** and **Dick Binder** who were key engineers developing hardware and fundamental people in the ALOHAnet implementation.

Two anecdotal situations



- Marisat was the first commercial use of an ALOHA Channel; exploited by COMSAT; they called it something else. And they were concerned in patent issues. Irving Goldstein (Chief Counsel) of COMSAT (the US representative in the INTELSAT international consortium) introduced me the company and took me to visit the engineers, and to everybody. He was with me during more than two hours when I just was going to discuss technology with some design engineers. I couldn't understand why one of the senior executives[13] directors of that huge company was spending so much time with me. Much later, when I left the university and started my own company, and had close relation with my lawyers, I understood that...they were concerned that we were looking for money of our

[11] CSMA/CD: Carrier Sense Multiple Access/Collision Detection. A carrier sense multiple access transmission scheme in which transmission resulting in collisions are followed by the transmitting stations backing off the network a random amount of time before attempting to retransmit. CSMA/CD is used as the basis of Ethernet networks. When multiple collisions occur for the same packet, Ethernet stations typically back off in exponentially increasingly large random time amounts to further reduce the probability of collision. Collision avoidance algorithms are also common in Ethernet, whereby a station will listen for silence on the media before transmitting. Definition taken from: www.voipdictionary.com

[12] IMP: Interface Message Processor. The predecessor of the actual router. TIP: Terminal Interface Processor. Special kind of IMP (simplified and less expensive) but with same functions. SIMP: Satellite Interface Message Processor.

[13] Later Irving Goldstein became the CEO and President of the Company.

invention. That's why the big lawyer of the company was all the time with me…

- The way we got the satellite IMP in Hawaii in early 1970's. ARPAnet started to grow fast. Larry Roberts while as Director of the ARPAnet project in his ARPA office in the Pentagon, had a list of the future nodes, and the future dates they had to be installed. He went off from his office, when his boss called him, and as I saw that our university in Hawaii was not in that list I inserted it with a random date 5 months later. Larry went back and I was going to tell him about that, but our conversation went to other topics, and I left the office without telling what I had done.
  Exactly five months later I had a call from Frank Heart (Director of the group in BBN who was building the IMPs and the ARPAnet) that in a week we should be prepared to install the Satellite IMP in Hawaii. We were amazed and we couldn't believe that. So then you can see the perfect planning of the Pentagon.

What do you think about the future of Internet?
It has a future as a society changing technology. What will be most important will be the pervasiveness of the network: how many places we can connect from. Not how much data we transmit from each place.

Do you see any technological trends?
Wi-Fi brings Ethernet to the ALOHA radio times again. Is like the end of a loop. But Wi-Fi is based in a single channel system and had a lot of problems which delayed its adoption. These problems were due to taking the Ethernet cable ideas (only one channel) and applying them in a radio setting. As we discussed before, the traffic towards the user is efficient, but from the user is random access and very inefficient. If you add both sources of traffic in one channel, everything becomes inefficient. So Wi-Fi is not as reliable as cable is. The real speed reached in an 11 Mbps connection (802.11b standard) its way way down below that. Mainly because is a single channel system. In places such as China they are trying to design their own systems, and considering a two channel Wi-Fi standard.

ADDITIONAL READING

PAPERS & BOOKS RELATED TO THE INTERVIEW

- **Robert Metcalfe** 1996. "*Packet Communication*". Computer Classics Revisited Series. Peer-to-Peer Communications, Inc. ISBN 1-57398-033-1. Page XVII
- **Paul Baran** , et al. *"On Distributed Communications"* The RAND Corporation. Santa Monica, CA Aug. 1964. **RAND Corp**, http://www.rand.org/publications/RM/baran.list.html
- **Stephen Segaller** 1998. "*Nerds 2.0.1 A brief history of the Internet"* ISBN 1-57500-106-3 TV Books LLC, (New York 1998) 399 pages.